On the loamy sand green, the K soil tests are not as high as in the loam soil at each rate of application. This is to be expected because of the low cation exchange capacity in the sandy soil. Typically, available K soil test levels are not high on sandy soils in spite of high rates of application. Because of the low cation exchange capacities and susceptibility to leaching of potash found in sands, it is necessary to apply potash more frequently and at lighter rates than on finer textured soils.

Based on the data generated thus far, we are reasonably confident in the potash recommendations made by our M.S.U. Soil Testing Lab. The levels of K maintained by the soil test based treatments as found in the 0-3 inch depth is holding about where we expect them to be. Recommendations for fertilizer applications should be based on soil samples taken from the top 3 inches or so of soil. In order to effectively compare soil tests from one year to another, always sample to the same depth and at the same time of year. Note that the soil K tests in the thatch layers are much higher than in the 0-3 inch soil depth in all 3 studies as would be expected. Thatch has lower density than soil.

One area of concern with very high levels of K is the potential for causing an imbalance between potassium and magnesium. In these studies, there is evidence that the magnesium soil test levels in the 0-3 and 3-6 inch soil depths are lower with high rates of application of potash. It is not yet a problem on these soils for 2 reasons: the level of magnesium in the soil is naturally high and the irrigation water used at the Hancock Turfgrass Research Center is very high in both calcium and magnesium. With each irrigation the turf receives a small amount of both calcium and magnesium. Many water sources in Michigan are high in calcium and magnesium, but some are not. Turf managers are urged to monitor magnesium soil test levels carefully if using high rates of potash on sites were magnesium tests are low or when the irrigation water is low in magnesium. Secondly, apply reasonable rates of potash. Most soil test recommendations for potash are acceptable. For heavy use turf areas, one might consider using 1 or 2 pounds of potash annually over that recommended based on soil tests. For maximum protection against the salt effects of potash carriers, we suggest application of only 1 lb. K_20 per 1000 sq. ft. per application when applied in dry form and watered in. One might go as high as 1.5 lbs under "safe" conditions of lower temperature and low relative humidity. The salt effects from fertilizers can cause the visual symptoms of foliar (and crown) burn, but could also be harmful to roots and soil biological activity. We do not have any proof of the latter under normal use of soluble fertilizers, but we do suggest care in not applying excessive rates at one time. It is essential to limit soluble fertilizer applications when the turf is in significant moisture stress. Fertilizers should never be applied when the turf is wilting.

Some agronomists are also concerned about getting the nitrogen to potassium ratio too wide. As a general rule, the higher the rate of nitrogen applied on high use turfs, the higher the rate of potash should be used. This should be related to soil test, of course. For example, if a golf course superintendent is using 5 pounds N per 1000 sq. ft. annually on a putting green and soil tests recommend 3.5 pounds potash, one could use 4.5 to 5.0 pounds potash annually if applications are made throughout the year. Watch magnesium soil tests, of course. However, if one is using only 2.5 pounds N annually and soil tests call for 3.5 pounds potash, the range of 3.5 to 4 pounds potash annually would be more appropriate. We have observed in other studies that with higher rates of N, there is greater loss of potassium. Some of this would come through leaching and some would be lost through greater clipping removal when clippings are not returned to the turf.

EFFECT OF FERTILIZER APPLICATION WITH THE HYDROJECT

A prototype of the Hydroject aerifier developed by the Toro Co. was used to inject phosphorus and potassium into turf soils. These studies were initiated in 1990 and continued in 1991. The phosphorus treatments were established on a Penncross creeping bentgrass green at the Hancock Turfgrass Research Center. Phosphorus treatments were as shown in Table 6: untreated check; Hydroject aerification alone; a surface application of 2.5 lbs. P_20_5 per 1000 sq. ft.; phosphorus applied at 2.5 or 5.0 lbs. P_20_5 per 1000 sq. ft.

Table 6. Effect of phosphorus placement on soil P tests. Penncross creeping bentgrass putting green. Loamy sand soil. Hancock Turfgrass Research Center. Initiated in 1990, repeated in 1991. Sampled November, 1991.

P_2O_5	Available P, lbs/acre			
lbs/1000	thatch	0-3 inch	3-6 inch	6-9 inch
Check	15c	25c	36c	44c
Hydroject alone	18c	24c	38c	50bc
Surface, 2.5	208a	66b	42c	46bc
Hydroject, 2.5	38c	64b	93b	58ab
Hydroject, 5.0	92b	116a	129a	66a

Table 7. Effect of potash placement on soil K tests. Annual bluegrass fairway turf. Loam soil. Hancock Turfgrass Research Center. Initiated in 1990, repeated in 1991. Sampled November, 1991.

K_2O	Available K, lbs/acre		
lbs/1000	0-3 inch	3-6 inch	6-9 inch
Check	93d	61d	65c
Hydroject alone	114d	84d	80bc
Surface, 3.0	234b	111c	82bc
Surface, 6.0	304a	158b	86bc
Hydroject, 3.0	175c	145b	97ab
Hydroject, 6.0	267ab	238a	112a

The phosphorus treatments were split into 2 applications during the growing season. Soil tests on samples taken in November 1991 are given in Table 6. It is clear that the phosphorus from surface applications is found mostly in the thatch and the 0-3 inch depth. Injecting the phosphorus clearly places the phosphorus deeper in the soil. The higher rate of phosphorus injected is much higher than would be recommended based on soil tests and obviously raises P levels deeper in the soil as would be expected. When P is applied only on the surface, roots deeper in the soil tend to extract P from that zone thereby leaving much lower P levels deeper in the root zone. The benefit from the deeper placement of P with the Hydroject is not yet apparent based on observations of the turf to date.

A similar study with potash was established in 1990 on an annual bluegrass turf mowed at fairway height and growing on loam soil. Treatments are similar to those for the P study, but the rates of application of K_20 (Table 7) are 3 and 6 lbs. per 1000 sq. ft. In this loam soil, there is limited downward movement of K from surface applications. This occurred for both 3 and 6 lb. treatments. When injected with the Hydroject, it is clear the K is being placed deeper in the soil after 2 years of treatments. Based on these studies, the conclusion is that the Hydroject can be used effectively to inject P and K in to turf soils. These studies will be continued to evaluate the benefits of nutrient injection to turf.

NITROGEN CARRIER EVALUATIONS

Several nitrogen carriers were evaluated for responses at the Hancock Turfgrass Research Center in 1991. One study was conducted on perennial ryegrass. Nitrogen was applied at the rate of 1 lb. N per application on 3 dates: May 15, July 8 and August 14. Plot size was 4 ft. by 6 ft. with 3 replications. Carriers evaluated in this study are shown in Table 8: Rejuvenate and 21-0-0 are from the Anderson's Co.; Lawn Restore is from the Ringer Co.; Milorganite from the Milwaukee Sewerage Commission; Sustane from the Sustane Co.; and Sun-Shine from the Sun-Shine Co. There is a clear response to the applied N based on turf quality rating starting 2 weeks after application. Although a few products gave a somewhat slower response initially, later in the season most gave consistent quality ratings. Clippings were collected on 5 dates during the growing season (Table 9) as another means of measuring response to the applied nitrogen. On 3 of the 5 dates there were significant differences from the untreated check. Generally, the clipping weight responses were consistent with turf quality ratings.

A similar study with the same treatments was established on Britsol Kentucky bluegrass. Turfgrass quality ratings (Table 10) and clipping weight measurements (Table 11) showed responses which were consistent with observations from the study on perennial ryegrass.

A study designed to evaluate the efficacy of a coated fertilizer developed by the Vicksburg Chemical Co. was established in May. Carriers included Multicote, the coated fertilizer; miniprilled potassium nitrate and urea. The N was applied at the rate of 4 lbs. N per 1000 sq. ft. for the season: the Multicote was applied at 2 lbs. N each on May 8 and July 5; the miniprill and urea were applied on 6 dates, May 8, May 29, June 19, July 5, August 5 and August 27. The Multicote fertilizer provided the highest quality ratings consistently through the season (Table 12), better than the other N carriers in spite of more frequent applications. Clipping weight data (Table 13) indicated that the Multicote treatment gave uniformly high growth rates in spite having been applied only 2 times during the growing season. These data point out this carrier has the potential to be applied 2 times per year and give uniform release nitrogen for turf needs.